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Ocular Injuries: Emergency Department Strategies

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CLINICAL CHALLENGES

- **Which** ocular injuries can be managed in the ED and which require emergent ophthalmology consultation?
- **What** is the role of imaging in the evaluation of ocular injuries?
- **How** should retrobulbar hemorrhage be managed in the ED if ophthalmology consult is not immediately available?

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■ Abstract

Ocular injuries are common in the emergency department, and they are the most frequent cause of noncongenital monocular blindness in children and adults. Systematic evaluation and management of ocular trauma patients will ensure these patients have the best chance for a favorable final visual outcome. This review provides evidence-based recommendations for the diagnosis, treatment, and disposition of patients with traumatic ocular injuries, including retrobulbar hemorrhage, traumatic hyphema, open globe injuries, ocular chemical burns, and corneal abrasions. The use of bedside ultrasound, antibiotics, cycloplegics, steroids, antifibrinolytics, and patching are also discussed.

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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) identify areas in practice that require modification to be consistent with current evidence in order to improve competence and performance; (2) develop strategies to accurately diagnose and treat both common and critical ED presentations; and (3) demonstrate informed medical decision-making based on the strongest clinical evidence.

CME Objectives: Upon completion of this activity, you should be able to: (1) diagnose traumatic ocular injuries and order proper imaging studies as necessary; (2) treat traumatic ocular injuries with the most current recommendations; and (3) identify which patients require admission to the hospital, which patients should follow up with ophthalmology, and when disposition should be at the discretion of the treating ophthalmologist.

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Introduction

Ocular injuries can be anxiety-provoking for both the patient and the emergency clinician. Traumatic eye complaints account for 3% of all emergency department (ED) visits in the United States,[1] where eye injuries are the leading cause of monocular blindness nationwide.[1-3] Eye injuries are also the most common cause of noncongenital unilateral blindness in the United States pediatric population.[4]

Fortunately, most eye injuries are minor and the overwhelming majority are not associated with significant morbidity.[5] Even most ocular burns tend to be mild and inconsequential in the long term.[6] In patients with mild injury, pain management and prevention of secondary infection are the mainstays of treatment. On the other hand, the multiply injured patient poses a particular clinical challenge because a proper eye examination may be difficult or impossible. This issue of *Emergency Medicine Practice: Trauma EXTRA!* reviews best-practice recommendations for the evaluation and treatment of ocular trauma patients based on the available evidence.

Etiology and Pathophysiology

Ocular trauma can occur as a direct consequence of either blunt or penetrating injury. It can also occur secondary to a blast injury; this is of particular importance in the setting of combat. Blast injury victims are especially prone to conjunctival laceration, subconjunctival hemorrhage, vitreous hemorrhage, and, occasionally,

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retinal tears and detachments.[7] For a basic schematic of the anatomy of the eye, see **Figure 1**. See **Figure 2** for a summary of many common ocular injuries.

Although it is important to discern the mechanism of injury, it is also important to note that many injuries can be caused by both blunt and penetrating trauma. For example, although open-globe injuries may be thought of as secondary to penetrating trauma only, the emergency clinician must be aware that blunt trauma can cause an open-globe injury.

Patients at particular risk for ocular trauma appear to be those at the extremes of age (ages 5-25 years and >70 years), men, and individuals of low socioeconomic status.[5] Children aged 5 to 8 years are at particularly high risk and tend to have more-serious injuries.[5,8] The workplace is a common environment for injury to occur, accounting for roughly 20% of all ocular injuries.[5,9] A prospective study of 5671 cases of ocular trauma in the United Kingdom revealed that no form of eye protection had been worn in 84.6% of cases.[8] Most cases of eye injury are preventable.[9] Preventive measures are both extremely important and extremely underutilized.

Figure 1. Eye Anatomy

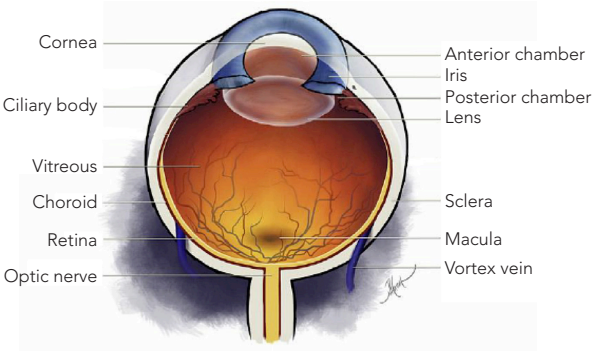

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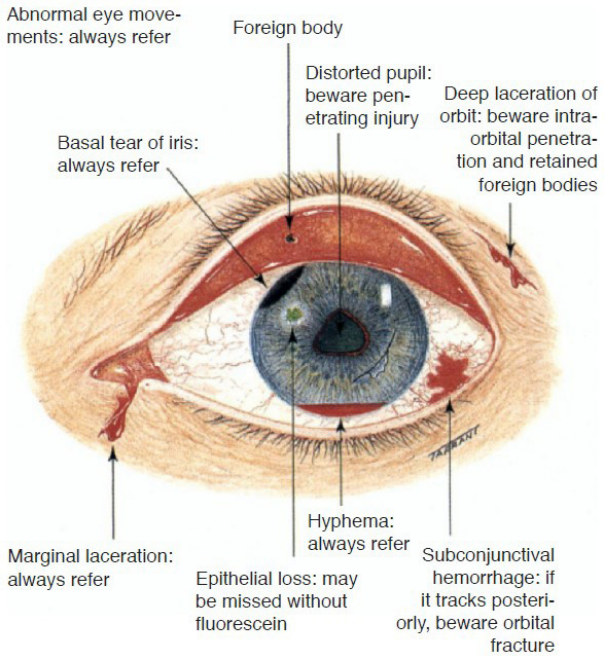
Figure 2. A Schematic of Grossly Visible Common Ocular Injuries


Abnormal eye movements: always refer
Foreign body
Distorted pupil: beware penetrating injury
Deep laceration of orbit: beware intraorbital penetration and retained foreign bodies
Basal tear of iris: always refer
Hyphema: always refer
Marginal laceration: always refer
Epithelial loss: may be missed without fluorescein
Subconjunctival hemorrhage: if it tracks posteriorly, beware orbital fracture

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From a pathophysiological standpoint, ocular injuries generally cause direct damage to the injured structure. This can cause bleeding in various locations in and around the orbit, lacerations and abrasions, and contusions that can damage the

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iris and ciliary body.[7] In other cases, the damage is indirect, such as in retrobulbar hemorrhage. Although retrobulbar hemorrhage involves bleeding, the real damage is due to optic nerve ischemia. It is postulated that the accumulation of blood in the orbital space, which has limited capacity for expansion, results in a compartment syndrome that can compress that optic nerve and/or its vascular supply.[10] However, the exact mechanism of this ischemia has yet to be elucidated.

■ Differential Diagnosis

Ocular injuries themselves will not cause mortality, but they do have the capacity to cause significant morbidity. **Table 1** lists possible diagnoses as a result of ocular trauma, grouped according to their ability to threaten the patient's vision. The majority of ocular injuries have the capacity for permanent vision loss, although not all vision-threatening injuries will cause permanent visual loss, and not all non–vision-threatening injuries are innocuous.

Table 1. Ocular Trauma Diagnoses

Vision-Threatening Injuries
- Open globe injury
- Retrobulbar hemorrhage
- Ocular burns
- Traumatic iritis
- Traumatic hyphema
- Retinal detachment
- Vitreous hemorrhage
- Posterior vitreous detachment
- Lens dislocation

Non–Vision-Threatening Injuries
- Corneal abrasion
- Subconjunctival hemorrhage
- Corneal foreign body

■ Prehospital Care

The overriding goal of prehospital care in the patient with ocular trauma is ensuring that the eye does not suffer any further damage during transport to the hospital.[2] Perhaps the most important patient group in which prehospital workers can affect visual outcome is patients with ocular chemical burns. Many authors have cited the immediate irrigation of the chemically burned eye as the most important factor in determining the patient's final visual acuity.[6,11,12] Chemical and conjunctival erosion is much more common in patients who are not irrigated before arrival (86%) than in those who are irrigated before arrival (24%).[13]

Fluids available to irrigate a chemically burned eye include lactated Ringer's solution, normal saline, normal saline adjusted to pH 7.4 with sodium bicarbonate, Balanced Saline Solution Plus® (BSS Plus®), or tap water. If tap water is all that is available, it should be used immediately.[2] A study from 1991 of 11 patients (12 eyes) found that BSS Plus® was tolerated the best by patients, followed by normal saline with sodium bicarbonate, lactated Ringer's solution, and finally, normal saline.[14] BSS Plus® is not widely available, requires reconstitution, and is significantly more expensive. Given that there have not been any sizeable trials to necessarily

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recommend one fluid over another, and they are all well tolerated, we recommend using the solution that is most readily available.

There are particular principles that should be employed to irrigate the eye properly. If contact lenses are in place, remove them or ask the patient to remove them in order to properly flush the eye. The irrigant should be directed toward the ipsilateral temple to avoid splashing into the contralateral eye. Effective high-volume irrigation can be achieved with intravenous tubing, wherein the patient's eye is held open as fluid runs out of the tubing directly onto the eye. If both eyes are affected, irrigant can be injected through nasal cannula prongs placed over the nasal bridge, with the oxygen tubing attached to intravenous tubing rather than an oxygen port. The irrigation should continue for 30 minutes, and the pH of the eye should be checked 5 to 10 minutes later. If the pH is not neutral (7.5-8) at that point, irrigation should recommence.[2,15]

If particulate matter is seen, it should be removed with a moistened cotton swab.[2] If a penetrating foreign body is noted, it should be left in place and not removed.[2,16] If an open-globe injury is noted or suspected, the affected eye should be protected without direct pressure on the globe itself. This can be accomplished with a commercial eye shield or a Styrofoam or plastic cup. Additionally, the head of the bed should be elevated to 30°, and pain, vomiting, agitation, hypertension, and Valsalva maneuvers should be controlled, as these can all raise intraocular pressure. If a traumatic hyphema is seen, open-globe precautions should be observed, as traumatic hyphema may be associated with open-globe injury.[2]

CASE 1

Your shift begins and you pick up your first chart: "Chemical splash in eye." The patient was at work when an unknown chemical splashed into her left eye. She immediately began irrigation, but she continues to complain of pain and decreased vision in the eye.

Should you examine the eye first or initiate irrigation of the eye immediately?

■ Emergency Department Evaluation

History

A detailed history and physical examination should be obtained in the ocular trauma patient. The only exception to this is in the case of ocular chemical burn, in which case irrigation is performed prior to the detailed history and physical examination. A list of pertinent historical questions is presented in **Table 2, page 7**. If the patient did not receive any irrigation in the prehospital setting, irrigation should be started immediately and continued for 30 minutes with no less than 1

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liter of fluid (irrigate with more volume for more significant exposures). If the patient was irrigated in the prehospital setting but remains symptomatic, irrigation should be restarted. Topical anesthetics such as tetracaine solution can be used to prevent pain and allow the patient to keep the eye open during irrigation. If the patient was irrigated in the prehospital setting and no longer complains of pain or burning in the eye, the pH can be checked, and if it is neutral, no further irrigation is necessary.

Table 2. Pertinent Historical Questions for Ocular Trauma Patients

- How did the injury occur?
- What are the circumstances surrounding the injury; ie, what was the patient doing when the injury occurred?
- Was eye protection used?
- When did the event occur?
- Is there any history of previous eye surgery?
- Is the patient wearing contact lenses?
- What medication(s) is the patient currently taking?
- Is there any history of hemoglobinopathy, especially sickle cell disease?
- Are there any subjective visual complaints?
- For ocular burns: What was the offending substance?

For all other patients, and for ocular burn patients who have completed irrigation, a specific set of questions needs to be addressed. In the patient with an ocular burn, ask the patient what the offending substance was, if known. In general, alkalis have a worse prognosis than acids and cause more ocular damage. Alkali substances are more lipophilic and penetrate rapidly and more deeply. An exception to this is hydrofluoric acid, which acts like an alkali.[2,17]

Determining how the injury occurred and what the patient was doing when the injury occurred will help guide the physical examination.[18] The circumstances surrounding the event should be carefully questioned. For example, was the patient hammering or performing any other metal-on-metal activity? If so, there should be a thorough examination for a foreign body, as metal is the most common ocular foreign body.[1] It must also be elicited whether the patient was working with organic or vegetable material at the time of the injury. These particles tend to have less momentum and are more likely to embed in the anterior globe, and they may not be visible on CT.[19] It should also be considered that strenuous physical activity (eg, lifting heavy boxes) can cause a retinal detachment; in this case, the heavy lifting was "traumatic," although it does not fit the traditional definition of trauma.[20]

The patient should be asked whether eye protection was used.[7] This has potential medicolegal implications and should be recorded in the patient's history. The patient should be asked when the injury occurred, as the timing may help narrow the differential diagnosis.[15] Traumatic iritis can present up to 3 days later, whereas

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retinal detachment may not appear until weeks after the injury.[21] Determining whether the patient has had an eye surgery in the past is important, as it has been noted that the rupture of wounds from prior surgery is a significant source of open-globe injury for elderly patients after a fall.[3]

Finally, an accurate list of the patient's current medications and any history of hemoglobinopathies should be obtained.[22] Anticoagulated patients are more likely to bleed and may suffer traumatic hyphema, retrobulbar hemorrhage, subconjunctival hemorrhage, and vitreous hemorrhage more easily than nonanticoagulated patients. Patients with sickle cell disease should not be given carbonic anhydrase inhibitors (a common component in the treatment of hyphema) because these increase the tendency of the red blood cells to sickle in the anterior chamber.[15,23] The patient should also be asked if they are subjectively having any visual problems, such as decreased visual acuity, or whether they are seeing any floaters.

CASE 1

For the patient with the chemical splash, you administered tetracaine eye drops to the affected eye and initiated immediate irrigation with lactated Ringer's solution. After 30 minutes of irrigation, the pH in her left eye was 7.5.

Physical Examination

The eye examination begins with a general observation, looking for evidence of trauma, deformity, or asymmetry. Visual acuity should be obtained and recorded for all patients.[7,18] It should be documented both initially as well as periodically throughout the patient's time in the ED, as deterioration may occur over time. Strong consideration should be given to consulting ophthalmology if there is deterioration of visual acuity, either initially or over time, as it is a sensitive sign of injury.[24] If a patient wears contact lenses or glasses, visual acuity should be measured with these corrective devices in place. If the patient's corrective device is not available, visual acuity without the device should be obtained and then performed again with a pinhole device; visual acuity abnormalities due to a refractive error should improve with a pinhole device.[25] If it is not feasible to obtain a formal visual acuity measurement, a rough estimate of the patient's visual acuity should be obtained. For example, ask if the patient can count fingers, see a hand waving, or perceive light. It is important to note that normal visual acuity does not exclude serious injury.[18]

The pupil should be examined, specifically looking at the shape, symmetry, red reflex, and reaction to light. An irregularly shaped pupil may indicate globe rupture, as seen in **Figure 3 on page 9**. Extraocular movements should be examined to ensure that the eyes can move freely in all directions. The anterior chamber should

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be examined for the presence of blood, which indicates a traumatic hyphema. **(See Figure 4.)**

A fluorescein examination should be performed to identify any corneal abrasions as well as to test for a possible ruptured globe via the Seidel test. Corneal abrasions are identified by uptake of fluorescein. If vertical or multiple linear abrasions are noted during the fluorescein examination (known as "ice-rink sign") **(see Figure 5)**, the eyelid should be everted to search for foreign bodies that may be trapped under the eyelid and causing repeated abrasions. The Seidel test involves instilling a large amount of fluorescein and examining the eye for a dark stream interrupting the fluorescein, which is an indication of globe rupture.[17] **(See Figure 6, page 10.)**

Fundoscopy and a portable slit-lamp examination can be performed to examine the cornea and iris to look for foreign bodies as well as for cells and flare seen in traumatic iritis (**see Figure 7, page 10**). The eye should be grossly inspected for any evidence of proptosis, which may indicate an underlying retrobulbar hemorrhage **(see Figure 8, page 11)**. Finally, intraocular pressure should be obtained via tonometry or by palpation of the globes if tonometry is not available.

There are some caveats to physical examination maneuvers. First,

Figure 3. Irregularly Shaped Pupil Secondary to Globe Rupture

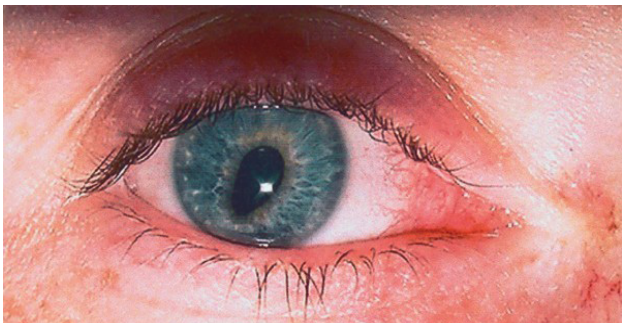

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Figure 4. Traumatic Hyphema

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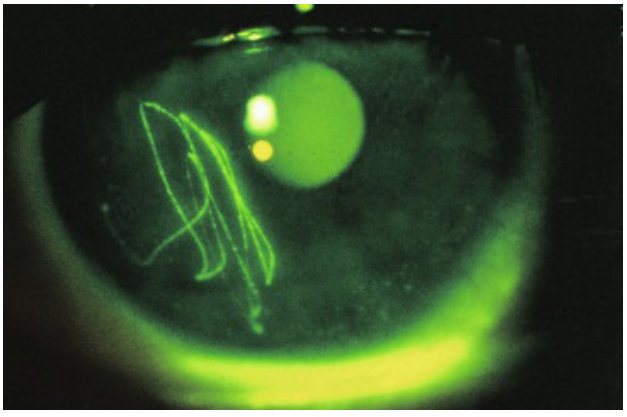
Figure 5. Corneal Abrasion With Multiple Linear Abrasions



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the physical examination of the patient should be tailored to that patient's specific complaint, and not all elements need to be performed on all patients. Also, if an open-globe injury is suspected or diagnosed, no pressure should be placed on the orbit, meaning that tonometry or palpation of the orbit should not be performed.[16,17] If rupture is obvious (ie, protrusion of intraocular contents), no further examination of the eye needs to be performed.[1] Finally, a high index of suspicion must be maintained for open-globe injury, as it may not be obvious. The defect may seal itself off, making the diagnosis on physical examination problematic.[3] In this case, the Seidel test will be negative, so emergency clinicians must be particularly vigilant.[26] Clinical findings suggestive of globe rupture include shallow anterior chamber, decreased intraocular pressure compared to the normal eye, bullous 360° bulbar subconjunctival hemorrhage, limited extraocular motility, pupil irregularity, and lens material in the anterior chamber.[1]

Figure 6. Positive Seidel Test Showing Traumatic Perforation of the Cornea

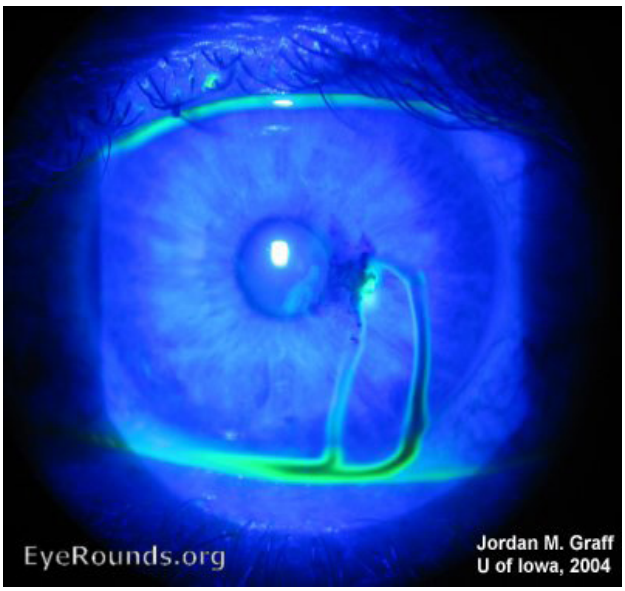

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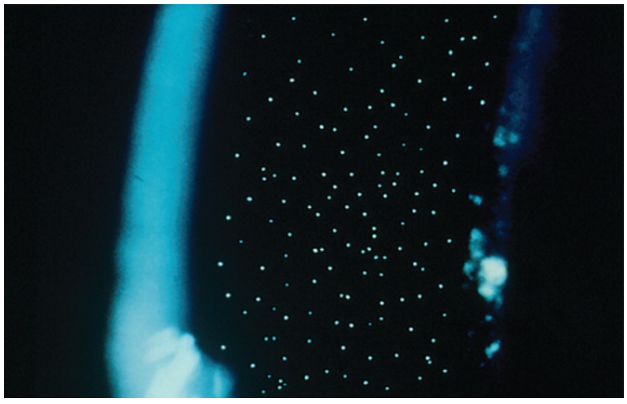
Figure 7. Anterior Chamber Cells Seen With a Slit Lamp



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The Multiply Injured Patient

The multiply injured trauma patient poses particular challenges. There may be life-threatening injuries present that preclude an assessment of the patient's eyes. The patient may be obtunded and unable to answer questions regarding his or her vision, pain, or ongoing changes in vision. There may also be significant swelling around the orbit, making evaluation of the orbit difficult or impossible.

Vision-threatening injuries should be considered at the end of the primary examination. Although orbital injuries tend not to affect mortality, they can have a

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profound impact on the patient's quality of life, and treatment of some injuries is time sensitive.[27]

In general, a brisk reaction to direct and consensual light stimuli in a round, concentric pupil is reliable in excluding a vision-threatening injury requiring immediate intervention.[27] However, if you are unable to examine the pupil or if the pupil is abnormal, the possibility of vision-threatening injury needs to be explored further. One option is to obtain an orbital computed tomography (CT) scan, although the patient must be stable enough to leave the ED. Another option is bedside ocular ultrasound, which is discussed in detail in the **Diagnostic Studies** section.

Figure 8. Proptotic Eye Secondary to Retrobulbar Hemorrhage

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CASE 2

You are called into the resuscitation area for a patient involved in a severe motor vehicle crash. The patient was apneic and was intubated by EMS. The right side of his face is extremely swollen, and you are unable to examine his right eye. The patient is unable to provide any information about the vision in his right eye. His eye seems mildly proptotic, and you wonder if you need to be concerned for a retrobulbar hemorrhage.

Is there anything that can be done at the bedside to evaluate for this possibility?

Proptosis and Retrobulbar Hemorrhage

Although retrobulbar hemorrhage is the most common cause of traumatic proptosis, other causes include bony displacement into the orbit (blow-in fracture) or swelling of the retrobulbar contents.[27,28] Differentiating between these 3 causes of proptosis is critical because retrobulbar hemorrhage is the only one of the causes of proptosis that can potentially benefit from a lateral canthotomy.

There are different ways to distinguish between the causes of proptosis. If the patient is able to communicate, a decrease in visual acuity would be worrisome and

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point toward a diagnosis of retrobulbar hemorrhage.[28,29] The same is true of an afferent pupillary defect, which can be obtained in a nonresponsive patient.[28,29] Other cardinal signs of retrobulbar hemorrhage are worsening proptosis, pain, and papilledema. Serial examinations are required to monitor for any of these changes. Measuring intraocular pressure may be helpful; intraocular pressure >40 mm Hg in a proptotic eye indicates that urgent treatment is required.[27,30]

From an imaging standpoint, bedside ultrasound or orbital CT can diagnose retrobulbar hemorrhage.[27,28] In any case, imaging should not delay treatment if the diagnosis has been made clinically.

■ Diagnostic Studies

In many cases of ocular trauma, the diagnosis will be made after a detailed history and physical examination are performed, and specific diagnostic testing will be unnecessary.

Laboratory Studies

Laboratory studies have limited utility in patients with ocular trauma. In coagulopathic patients or patients unable to provide a reliable history, obtain prothrombin time and partial thromboplastin time. If a Black patient presents with a traumatic hyphema, inquire about or screen for sickle cell disease or sickle cell trait, as patients with these conditions have a higher incidence of secondary hemorrhage.[31]

Computed Tomography

CT of the orbit is the modality of choice for traumatic globe injury in the ED.[32] Helical CT is often recommended over conventional CT because it is quicker and involves less radiation exposure.[33] **Figure 9** shows a CT of an eye with a glass intraocular foreign body.

Although CT is often considered the gold standard, it has limitations. First, vegetable foreign bodies can be missed on CT. If a vegetable foreign body is suspected but not identified on CT, surgical exploration may be indicated.[33] Magnetic resonance imaging is also an option in this situation (assuming a metallic foreign body has been excluded).[19] Finally, although CT has been

Figure 9. Computed Tomography Image Showing Glass Intraocular Foreign Body

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found to be 100% sensitive for foreign bodies larger than 0.06 mm^3, it is only 65% sensitive for foreign bodies smaller than this.[19]

Ultrasound

Bedside ocular ultrasound is easily accessible, inexpensive, well-tolerated, and does not require patients to leave the ED.[28] It is particularly useful in blunt trauma when there may be too much soft-tissue swelling to retract the eyelids and examine the orbit properly.[34] It can be performed quickly, typically in 60 to 90 seconds even in difficult cases, and is also very accurate.[17,34] One prospective observational study of 61 patients with ocular trauma showed 100% sensitivity and 97.2% specificity when compared with CT, with minimal training of the emergency physician.[34] A normal ultrasound of an uninjured orbit can be seen in **Figure 10. Figure 11** is an ocular ultrasound of retrobulbar hemorrhage, and **Figure 12 on page 14** is an ultrasound showing retinal detachment.

If bedside ocular ultrasound is undertaken, it is recommended to a use a 7.5 to 10 MHz linear array transducer, and the orbit should be scanned in both the long and short axes.[35] A large amount of gel should be used over a closed eyelid; sterile gel is not necessary.[36] If globe rupture is a concern, the preferred imaging modality is CT. Ocular ultrasound may be safe given the large amount of gel that

Figure 10. Normal Ocular Ultrasound

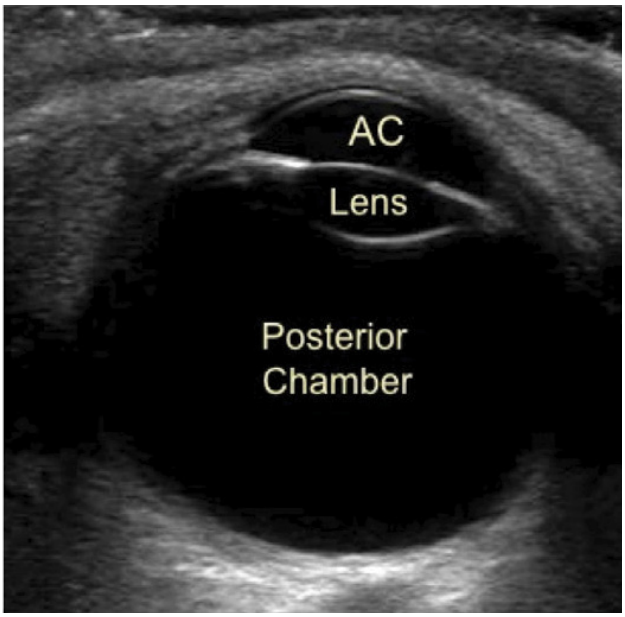

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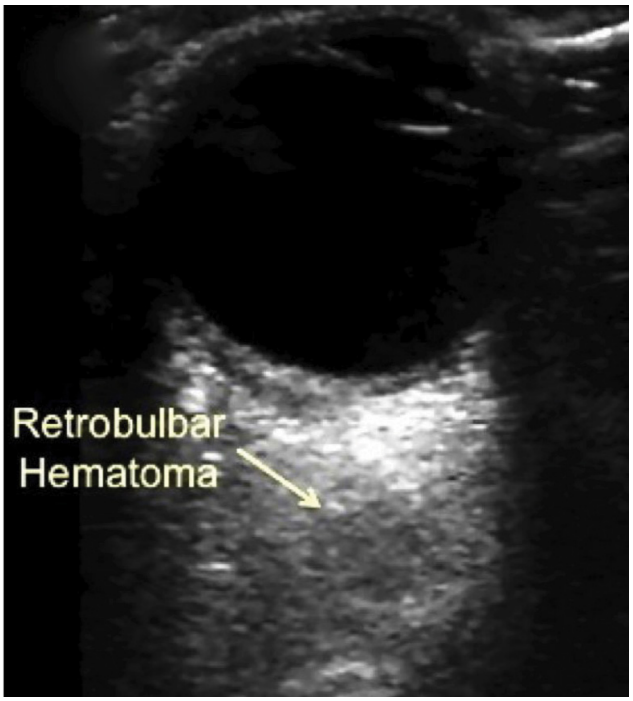
Figure 11. Ocular Ultrasound Showing Retrobulbar Hemorrhage



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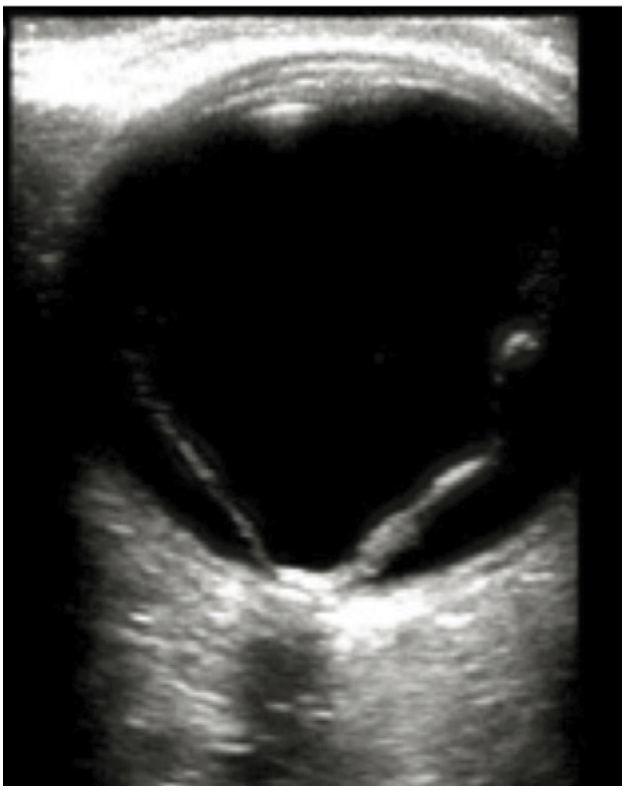
is used, however, there are some who feel ultrasound usage is contraindicated among patients with suspected globe rupture.[1,35,37]

The indicator on the ultrasound probe should be oriented either towards the patient's head or the patient's right side. The gain may need to be increased during the examination to diagnose more subtle findings. If the patient is cooperative, it may be helpful to have them look in different directions so that no pathology is missed.[36] **Table 3** lists conditions that may be diagnosed by ocular ultrasound, with associated ultrasound findings.

When using ultrasound to identify possible foreign bodies, a false positive may be obtained if there is intraorbital air, as it may mimic a solid foreign body.[19] It is preferable to examine the patient upright, although this may not be possible for trauma patients.[36]

Figure 12. Ocular Ultrasound Showing a Complete Retinal Detachment



Note that the retina remains attached to its firm attachment points at the ora serrata bilaterally and the optic nerve head posteriorly producing the classic V shape on ultrasound.
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Table 3. Conditions Diagnosable By Ultrasound and Their Characteristic Findings

Condition	Ultrasound Finding
Vitreous hemorrhage	• String-like echogenicities throughout the vitreous
Retrobulbar hemorrhage	• Hypoechoic fluid behind the globe **(see Figure 11, page 13)** • The posterior globe may have a conical deformation that resolves after lateral canthotomy[38]
Lens dislocation	• Lens will be seen in an abnormal location in the globe
Intraocular foreign body	• Not always visible, but if seen, will be distinct echogenic area in or around the globe
Retinal detachment	• Thick, irregular band seen at the area of detachment in the globe[39] **(see Figure 12)**
Globe rupture	• Loss of intraocular volume with a distorted size and shape of the globe[36]
Posterior vitreous detachment	• Thin, smooth membrane that may remain attached to the retina. High gain is required[40]

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CASE 2

After a FAST examination was performed on your motor vehicle crash patient, you decided to perform a bedside ocular ultrasound, which revealed a retrobulbar hemorrhage. Ophthalmology consultation in the ED is currently unavailable.

What should you do to treat this high-acuity patient with a potentially time-sensitive diagnosis?

Treatment

Retrobulbar Hemorrhage

Retrobulbar hemorrhage is a serious, vision-threatening injury and must be treated expeditiously. Once ischemia to the optic nerve begins, permanent vision loss can occur within 60 to 120 minutes.[1,17] Treatment of retrobulbar hemorrhage can be both surgical and medical. Although most emergency physicians are aware of the lateral canthotomy to surgically treat retrobulbar hemorrhage, a survey of emergency physicians indicated that most of them did not know proper medical management of this condition.[29] The emergency physician has several options, depending on the severity of the patient's symptoms and physical examination findings.

Ideally, ophthalmology is consulted emergently, and the treating ophthalmologist can manage the retrobulbar hemorrhage, but this is not always available in a timely manner. If it is not, the emergency physician must be prepared to manage the patient's retrobulbar hemorrhage.[10] If the clinical diagnosis is obvious and not in question, a lateral canthotomy with inferior cantholysis should be performed.[30]

Permanent visual damage is unlikely if decompression is performed within 2 hours of symptom onset.[30] The lateral canthus should be anesthetized with lidocaine with epinephrine, then a tissue clamp is placed horizontally across the lateral canthus for 1 to 2 minutes. The lateral canthus has an inferior crus (branch) and a superior crus. Incising the inferior crus relieves intraorbital pressure; therefore, begin by using sterile scissors to cut the inferior crus with an approximately 1-cm incision.[10,30] If the intraocular pressure is not relieved, proceed with cutting the superior crus; it is not unreasonable to simply cut the inferior and superior ligaments as part of the lateral canthotomy procedure and then proceed to rechecking the intraocular pressure.[10]

Medical management should be considered in addition to the surgical decompression with a lateral canthotomy. Some authors recommend that any patient receiving a lateral canthotomy should also be provided with medical management, including intravenous corticosteroids, mannitol, and acetazolamide.[30] Lateral canthotomy should never be delayed while awaiting medical management.

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If symptoms are equivocal and definitive testing is not possible (for any reason), medical management with mannitol, corticosteroids, and acetazolamide should be provided; surgical decompression should be performed if symptoms do not improve with medical management alone. Recommended dosages for these medications (all given intravenously) are: 20% mannitol, 2 g/kg; methylprednisolone, 250 mg, or hydrocortisone, 100 mg; and acetazolamide, 250 to 500 mg.[29,30,41] Care must be used if the patient is hypotensive, as mannitol and acetazolamide may worsen hypotension.[27,28]

CASE 2

You immediately performed a lateral canthotomy and inferior cantholysis, with resolution of the proptosis. Visual acuity in the patient's right eye was 20/30 at the time of discharge 1 week later.

Open-Globe Injuries

Open-globe injuries are vision-threatening and require immediate ophthalmology consultation. One of the most important aspects of treatment is to prevent further injury. The head of the bed should be placed at 30°, a rigid metal shield should be applied, and analgesics and antiemetics should be given to control pain and nausea/vomiting.[1] Tetanus prophylaxis should be provided as needed.[1,3]

Antibiotics are generally recommended for prophylaxis against posttraumatic endophthalmitis, despite the absence of strong evidence for benefit. Treatment regimens vary; we recommend ceftazidime 1 g every 8 hours and vancomycin 1 g every 12 hours, both for 48 hours, in addition to topical antibiotics.

CASE 3

Your next patient presents to the ED after being involved in a bar brawl. He sustained a blow to his right eye during the altercation and is experiencing pain and vision loss in the eye. On gross inspection of the eye, you see blood accumulated in the anterior chamber and suspect traumatic hyphema.

How should you treat this patient? What should you rule out prior to initiating treatment?

Traumatic Hyphema

The management of traumatic hyphema is controversial with regard to both treatment and disposition. It has been traditionally recommended that all patients with traumatic hyphema be admitted to the hospital and placed on strict bed rest, with both eyes patched.[22] The goal of treating hyphema is to prevent

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secondary hemorrhage (also called rebleeding). Rebleeding occurs in roughly 22% of cases and may result in permanent vision loss secondary to glaucoma, optic nerve damage, and corneal blood staining.[22,42] Topical miotics and cycloplegics have not been found to have a significant effect in preventing rebleeding, although they have been traditionally used.[22,43]

Patching

Eye patching may afford the patient with traumatic hyphema some benefit, according to some studies. One review article found patching increased patient comfort and prevented re-injury, and the authors advocated for the use of patching in both the inpatient and outpatient settings.[22] While bilateral patching has been classically recommended, both the aforementioned review and a 2023 Cochrane review of traumatic hyphema found no benefit to binocular versus monocular patching in terms of rates of rebleeding or final visual outcome.[22,43] Only 1 comparative study in the Cochrane review included patients who received no patching at all, and it found no benefit in terms of healing time, rebleeding rate, or final visual acuity.[43] While patching may decrease subjective patient complaints, robust evidence as to its medical benefit is lacking.

Corticosteroids

Topical or systemic corticosteroid use is an area of controversy, and review articles provide conflicting recommendations regarding use to prevent rebleeding.[22,42] A randomized controlled trial of 43 patients found no difference in rebleeding or final visual acuity in patients receiving oral prednisone versus placebo.[44] A 2023 Cochrane review did not find any benefit to the use of corticosteroids in reducing the rate of rebleeding; however, the authors noted that the studies examining this particular question are small.[43]

Antifibrinolytics

Antifibrinolytics, specifically aminocaproic acid and tranexamic acid, are commonly used in the treatment of traumatic hyphema. It has been generally accepted that antifibrinolytics decrease the rate of rebleeding, but whether this has an effect on the patient's final visual acuity is questionable.[22,42] One study of 215 pediatric patients found no significant difference in rebleeding rates between groups given oral tranexamic acid or placebo ($P = 0.6$).[45]

A common problem with aminocaproic acid is that it has many adverse effects, including nausea, vomiting, dizziness, and syncope.[43] These adverse effects can render the drug difficult or impossible to use, particularly in the outpatient setting. Topical aminocaproic acid is an alternative to oral aminocaproic acid. One randomized controlled trial of topical aminocaproic acid versus placebo gel showed favorable trends towards decreasing rebleeding and improving vision, but neither was statistically significant, secondary to small sample size.[46] Although more research is required, topical aminocaproic acid appears to be a promising

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tool in the management of traumatic hyphema, as it avoids the adverse effects of the systemic antifibrinolytics.

A particular problem in the studies of topical and systemic antifibrinolytics is the patient population that is studied. Patients with sickle cell disease and other coagulopathies are at higher risk for complications of hyphema.[47] However, in many studies, the patients were predominantly White. Because sickle cell disease is rare in this population, the results of these studies may be skewed and inapplicable to the general population. For example, a study of 238 patients showed that oral tranexamic acid decreased rebleeding, but all of the patients in the study were White.[48] Nevertheless, the 2023 Cochrane review did find that systemic aminocaproic acid, topical aminocaproic acid, and tranexamic acid all reduced the rate of rebleeding, although it did not advocate for any particular treatment over the others.[43]

Summary

Antifibrinolytics may reduce rebleeding, and all other therapies (eg, corticosteroids, cycloplegics, miotics, aspirin, conjugated estrogens, traditional Chinese medicine, eye patching, elevation of the head, and bed rest) have not been found to be helpful per the 2023 Cochrane review.[43] Ophthalmology should be consulted for all cases of traumatic hyphema, and further treatment decisions should be made in conjunction with the treating ophthalmologist.

CASE 3

You diagnosed your patient from the bar brawl with a traumatic hyphema, but you also conducted a careful and thorough physical exam to look for signs of open-globe injury and orbital compartment syndrome, which must be ruled out prior to initiating treatment. You did not elicit any concerning findings, so you administered topical tetracaine for analgesia and requested ophthalmology consultation. In the meantime, you gave the patient an eye shield, brought him to a dim section of the ED, and instructed strict bed rest with the head of the bed elevated 30° to promote inferior settling of blood in the anterior chamber.

Traumatic Iritis

Most commonly, traumatic iritis presents within 3 days of the patient experiencing blunt trauma. The patient will generally complain of pain, decreased vision, tearing, and photophobia. The typical finding on slit-lamp examination in these patients is cells and flare in the anterior chamber **(see Figure 7, page 10)**; other findings include decreased vision and conjunctival injection around the limbus.[15]

Traumatic iritis receives surprisingly little mention in the ocular trauma literature, and no relevant, quality clinical trials regarding its management in the ED were

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found. The traditional treatment for traumatic iritis has been use of topical cycloplegics with close ophthalmology follow-up (cyclopentolate 2%, 3 times per day until ophthalmology follow-up).[7,15] Topical steroid application is also considered first-line treatment, but typically should not be initiated without a consulting ophthalmologist. A Cochrane review on treatment of topical mydriatics as adjuncts to topical steroids did not find any eligible randomized controlled trials to analyze and therefore did not draw conclusions.[49]

CASE 1

After adequate irrigation in the ED, the patient with the chemical splash feels better.

Should you consult ophthalmology in the ED at this point? What medications should you send home with this patient?

Ocular Chemical Burns

Copious irrigation is the mainstay of treatment of ocular chemical burns. The offending compound should never be neutralized, as neutralization produces heat and further damage can ensue.[15,50] If irrigation is necessary in the ED, first anesthetize (typically with tetracaine) and then flush with a high volume of fluid. Consider the use of a Morgan Lens™, if available. The Morgan Lens™ is placed under the upper eyelid, then under the lower eyelid. Fluid runs through the lens and then rolls off of the patient's eye. It should not be used if the presence of a foreign body is suspected.[50] Another option for direct irrigation is intravenous tubing, as described in the **Prehospital** section. The patient should be irrigated with at least 2 liters of normal saline, lactated Ringer's solution, balanced salt solution, or water.[16] Five to 10 minutes after irrigation, the pH of the eye should be tested and irrigation should continue if the pH is not neutral. The length of time of irrigation, the solution used, the pH of the eye, and the number of times the pH of the eye was tested should all be recorded.[51]

Once irrigation is complete, the severity of the burn should be assessed, as this will affect management and disposition of the patient. The Roper-Hall classification system, presented in **Table 4 on page 20**, is commonly used to grade burn severity based on the degree of corneal injury and limbal ischemia (ie, blanching) as seen on slit-lamp examination.[15] A photograph of a Roper-Hall grade IV injury is seen in **Figure 13 on page 20**.[15]

Traditional treatment for grades I and II ocular burns has included topical antibiotics and artificial tears, whereas grades III and IV were treated with topical steroids, ascorbate, citrate drops, and hospital admission.[16] Both ascorbate and citrate have been studied in depth in rabbits, and have proven to be beneficial;

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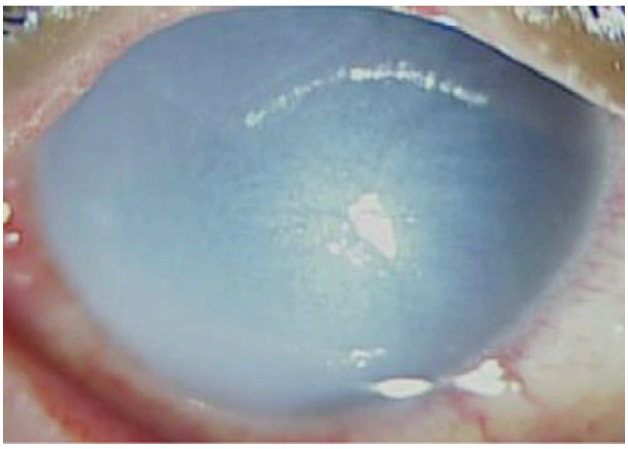
however, data regarding their efficacy in humans are lacking.[11,52] Topical dexamethasone was studied in rabbits with alkali burns and results suggested that its administration may help endothelial healing; however, a review of human patients did not support this.[41,53] The decision to use any of these medications should be made in conjunction with the treating ophthalmologist.[15]

Figure 13. Roper-Hall Grade IV Ocular Burn



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In summary, for ocular burns in the ED, the eye should be thoroughly irrigated, a topical antibiotic should be applied, and all other medications given should be at the discretion of the treating ophthalmologist. The patient should receive a tetanus immunization as necessary.[17]

Table 4. The Roper-Hall Classification System

Grade	Prognosis	Corneal Condition	Conjunctival Limbus
I	Good	Corneal epithelial damage	No limbal ischemia
II	Good	Corneal haze and iris details visible	<1/3 limbal ischemia
III	Guarded	Total epithelial loss, stromal haze, and iris details obscured	1/3 to ½ limbal ischemia
IV	Poor	Cornea opaque and iris and pupil obscured	>½ limbal ischemia

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CASE 1

Upon examination of your patient with the chemical splash, you were concerned that she may have sustained a Roper-Hall grade III burn. You consulted ophthalmology, who agreed with your assessment and admitted the patient for intensive treatment with topical steroids and topical antibiotics, as well as ascorbate and citrate.

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Retinal Detachment, Posterior Vitreous Detachment, Vitreous Hemorrhage, and Lens Dislocation

Retinal detachment, posterior vitreous detachment, vitreous hemorrhage, and lens dislocation may have similar features, making them difficult to distinguish on clinical grounds. Retinal detachment, posterior vitreous detachment, and vitreous hemorrhage can all cause the patient to see floaters or flashes of light, and can cause blurred vision or visual loss.[37,54] Lens dislocation can cause pain, blurred or double vision, and photosensitivity.[37]

Patients with complaints suspicious for any of these diagnoses should have a thorough ocular examination performed. As mentioned previously, advanced imaging (such as ultrasound) can help distinguish these entities. Although no intervention needs to be performed by the emergency clinician, ophthalmology should be consulted emergently if any of these diagnoses are suspected.[1,55,56]

Corneal Foreign Body

If a corneal foreign body is identified, it should be removed if it is not penetrating. Removal should be first attempted with irrigation. If this is unsuccessful, a moistened cotton swab can be used.[1,18,50] If this is still unsuccessful, a 25-gauge needle can be used, but an experienced clinician should perform this procedure.[50,57] If a rust ring is present, it should be removed within 24 hours, but it does not necessarily need to be removed by the emergency clinician.[50]

Corneal Abrasion

Practice patterns for treatment of corneal abrasion are highly variable and controversial. Previous treatment included some combination of topical antibiotics, cycloplegics, pain management, and eye patching. However, many studies have concluded that patching may be harmful because it decreases the rate of healing and binocular vision.[39,58,59] Few studies have evaluated cycloplegics in corneal abrasion, and there is no evidence of benefit.[60,61] Therefore, we do not recommend patching the affected eye, and cycloplegics probably should not be given.

Topical nonsteroidal anti-inflammatory drugs (NSAIDs) for corneal abrasion have been studied extensively and have been found helpful in decreasing pain in the first 24 to 48 hours without adverse effects on healing.[61-65] Emergency clinicians should feel comfortable prescribing topical NSAIDs for corneal abrasions. While 2 meta-analyses of randomized control trials found topical NSAIDs to be effective analgesics for traumatic corneal abrasions, a Cochrane review on this topic concluded that there is no strong evidence to support their use.[61,63,66]

Data supporting the use of antibiotics for uncomplicated corneal abrasion are also admittedly lacking, despite this being common practice. A 2022 Cochrane review found no randomized control trials that compared antibiotics with placebo versus no treatment for corneal abrasion.[67] For lack of concrete evidence

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to suggest otherwise, erythromycin ophthalmic ointment should be used 4 times per day for 3 to 5 days for simple corneal abrasion in non–contact lens wearers. Patients who wear contact lenses require antipseudomonal coverage and daily evaluation until the abrasion heals.[15] These patients can be given levofloxacin 0.5% solution to be used (1-2 drops) every 2 hours, while awake, for 2 days, then every 4 to 8 hours for 5 days.

CASE 3

The patient with traumatic hyphema is still awaiting ophthalmology evaluation.

You are concerned about rebleeding risk and wonder, "Does this patient need to be admitted?"

■ Disposition

Retrobulbar Hemorrhage

A patient with a confirmed retrobulbar hemorrhage needs emergent ophthalmology consultation and admission to monitor for any change in vision. Compromised visual acuity in a patient with elevated intraocular pressure or other clinical signs of retrobulbar hemorrhage warrants immediate treatment.

Traumatic Hyphema

There is a movement towards discharging home patients with traumatic hyphema. A retrospective study of 314 cases of traumatic hyphema supports this stance, with the authors stating that an argument can be made in favor of permitting patients with hyphema to be discharged with guidance to strictly limit physical activity and promptly seek medical attention for any symptoms of a rebleed.[68] This study did not find any factor (age, sex, mechanism of injury, grade of initial hyphema) to increase the risk of rebleeding. The patients in the study who did experience rebleeding experienced no adverse effect on their visual outcome. Another study of 238 patients found low vision and elevated intraocular pressure to increase the chance of rebleeding.[48] A retrospective review of 37 cases at a single clinic not only reported adequate visual outcomes with outpatient management, but found that no patients experienced rebleeding, despite not receiving antifibrinolytics.[69]

A retrospective chart review of 154 patients with traumatic hyphema also leans towards outpatient management, arguing that the patients in the study who did have adverse visual outcomes would not have had their clinical course improved with hospitalization. However, this patient population was predominantly White and was very compliant with follow-up. The authors' final recommendation was to admit patients with intractable elevated intraocular pressure, rebleeding, or

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predicted poor compliance, and to consider admission in patients with severely decreased vision, total hyphema, or a history of sickle cell disease.[70] Another author advocates for the admission of patients with hyphemas >50% in size and consultation of ophthalmology in all cases.[22]

Given the controversial nature of the disposition of the patient with traumatic hyphema, ophthalmology should be consulted in the ED for management of these patients. Special attention should be paid to patients who may be non-compliant or will have difficulty following up with an ophthalmologist. However, if the patient is able to follow up, the emergency clinician should be aware that the patient may be discharged home. An in-person ophthalmology consult may not be necessary, particularly with the ease of sharing photographic images and telemedicine consultation; however, traumatic hyphemas of any significance certainly require a discussion with an ophthalmology consultant.

CASE 3

You determined that your patient with hyphema does not have elevated risk of rebleeding and can be feasibly monitored as an outpatient. Based on your focused interview, the patient denied both personal and family history of sickle cell disease, other hemoglobinopathy, or coagulopathy. He also denied taking any medications that cause bleeding tendency. You measured intraocular pressure in the injured eye, which was within the upper limit of normal. You counseled the patient on the importance of strict activity limitation, keeping the head of bed elevated to 30° at home if possible, and attending follow-up appointments with the outpatient ophthalmologist; the patient verbalized understanding. You discussed the case with the consulting ophthalmologist, who agreed with you to discharge the patient home for continued management as an outpatient.

Ocular Burn

Disposition of the patient with an ocular burn depends on the severity of the burn. A comparative study of 121 patients (177 eyes) showed that intensive inpatient treatment with ascorbate and citrate was actually harmful in patients with grade I or II injury and recommended against routine admission of these patients.[11] Given that the optimal management of patients with ocular burns has not yet been established, it is prudent to make a disposition decision after discussion with an ophthalmologist. Patients with grade III or IV injury almost certainly require admission.

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Other Injuries

The disposition of other injuries is more straightforward. Patients with open-globe injuries require ophthalmology consultation in the ED to prevent post-traumatic endophthalmitis and for treatment of the injury.[42,71] At the other end of the spectrum, patients with traumatic iritis or subconjunctival hemorrhage can generally be safely discharged home with ophthalmology follow-up. Patients with corneal foreign bodies can be discharged home if the foreign body was successfully removed. If the patient has a rust ring, follow-up with ophthalmology should occur within 24 hours. If removal of the corneal foreign body results in a corneal abrasion, then the patient should be treated for the corneal abrasion.

Most patients with a corneal abrasion can be discharged home. Circumstances under which ophthalmology should be consulted in the ED are: (1) the presence of significant visual deficits; (2) injury that is associated with a corneal infiltrate or ulcer; or (3) corneal abrasion due to a penetrating eye injury. In general, the patient should be instructed to follow up with an ophthalmologist within 1 day; however, ophthalmology follow-up is generally unnecessary if the abrasion is <4 mm, provided there are no visual acuity deficits and the patient's symptoms are improving.[15]

Retinal detachment, vitreous hemorrhage, posterior vitreous detachment, and lens dislocation all require evaluation by an ophthalmologist and will very likely require hospital admission, as repair in the operating room may be required.[54,55]

■ Controversies and Cutting Edge

Topical Anesthetics for Corneal Abrasion

The use of topical anesthetics, long regarded as dangerous and with no role to play in the outpatient management of patients with corneal abrasion, has been the subject of study. Studies of topical anesthetics have yielded conflicting results. It appears that usage of topical anesthetics for <48 hours is probably not harmful, but may not actually improve pain control.[72,73] Prolonged use of topical anesthetics can be harmful and has the potential to cause blindness.[74] Given the conflicting data regarding topical anesthetics, more research is necessary before most clinicians will feel comfortable prescribing them for their patients.

Lateral Canthotomy Training

Studies suggest that lateral canthotomy and cantholysis should be performed within 2 hours from the onset of orbital compartment syndrome to achieve optimal visual outcomes.[75] Although emergency physicians are often the first to treat patients who may need lateral canthotomy, certification is currently not required by the Accreditation Council for Graduate Medical Education training curriculum. Delays in treatment have been linked in part to emergency physician hesitancy and discomfort with performing lateral canthotomy, given the low incidence of orbital compartment syndrome.[76,77] A prospective cohort study on the manage-

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ment of retrobulbar hemorrhage by nonophthalmologic emergency physicians found that only 37.1% of 190 participating physicians reported that they would perform lateral canthotomy themselves. Furthermore, 91.4% cited lack of training as the reason for their unwillingness to personally perform the procedure.[78] Interestingly, one retrospective study found that the success rate of lateral canthotomy and cantholysis is comparable between emergency physicians and ophthalmologists: 68% versus 79.2%, respectively ($P = 0.413$).[77] These findings indicate a need for increased emergency physician confidence and willingness to perform these high-stakes interventions.

Various educational models are being developed to improve clinician training and confidence in lateral canthotomy. Cadaveric and animal models (eg, porcine) have historically been used and shown to be effective, but they may be cost prohibitive, logistically challenging, and not suitable for repetition.[79,80] Synthetic high-fidelity trainers are likewise expensive, which may be problematic for resource-limited centers. Several studies have proposed low-fidelity trainers made of inexpensive, easily accessible materials, which can be found or stored in the ED; these studies reported high usability and usefulness ratings by physicians.[76,81,82] Such models can be widely distributed, although they do not provide the anatomic accuracy of cadaveric and animal trainers or the situational realism of high-fidelity trainers that simulate details such as proptosis and bleeding. Training programs may choose to utilize a combination of these models to provide a comprehensive and effective learning experience for clinicians and improve patient outcomes.

Hospital Admission for Traumatic Hyphema

In addition to conflicting opinions regarding the optimal medical management of patients with traumatic hyphema, there is significant debate regarding whether patients with traumatic hyphema require routine admission to the hospital. Antifibrinolytics can be given topically, and other treatment modalities such as bed rest and eye patching can be done at home, leading some to argue that routine admission is no longer necessary, assuming the patient is able to follow up with ophthalmology.

The pediatric population has been of particular interest to researchers of this topic. A prospective case series of 35 children with traumatic hyphema treated in the outpatient setting was examined.[4] Elevated intraocular pressure was not an exclusion criterion; these patients were treated with timolol if their intraocular pressure was >24 mm Hg and were discharged home. The patients were not given antifibrinolytic agents. The rebleeding rate in this population was 8.6%, which is reasonable given that rebleeding rates in the literature range from 3.5% to 38%.[43] Patients did undergo daily follow-up examinations by an ophthalmologist. This study demonstrates that outpatient management of traumatic hyphema

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is possible, but very close follow-up must be assured.[4] A retrospective chart review of 138 pediatric patients with hyphema also supports the notion that this injury can be managed in the outpatient setting. No one in this study experienced rebleeding.[83]

Oxygen Therapy for Ocular Burns

Oxygen therapy may be a promising adjunct to the treatment of severe ocular burns. A prospective comparative case series of 22 patients (24 eyes) studied the effects of oxygen in patients with grade III to IV ocular burns that were a result of either thermal or chemical damage. The patients received 100% oxygen delivered via simple mask at a rate of 10 L/min for 1 hour, twice daily, in addition to "standard" medical therapy (the medical therapy was at the discretion of the treating physician and was not standardized). It was found that the patients receiving oxygen experienced quicker healing of their corneal defects (15.23 days vs 59.9 days, $P < .001$), quicker revascularization of ischemic areas (14.54 days vs 45.09 days, $P = .001$), and improved final visual acuity as measured by the logarithm of the minimal angle of resolution (0.40 vs 1.11, $P = .018$).[84]

■ Summary

Ocular trauma is a serious cause of morbidity and a leading cause of blindness in all populations. Most of these injuries are preventable, as many people do not wear proper eye protection. When patients present to the ED with a traumatized eye, the absolute first consideration is immediate irrigation if the patient has an ocular chemical burn. Otherwise, a thorough history should be taken, with special attention paid to the patient's ocular history, as well as any history of acquired or congenital coagulopathy or sickle cell disease or trait. The patient's orbit and surrounding structures should be examined both grossly as well as with the assistance of fluorescein staining, a slit-lamp, and fundoscopy. Visual acuity must be measured. Special care must be taken in multiple trauma patients, as they may not be able to provide any information regarding ocular pain or vision changes; clinical examination, ultrasound, and CT are particularly helpful in these patients.

If a vision-threatening injury is suspected, ophthalmology should be consulted, and the patient will likely require advanced imaging and possible hospital admission. Patients with more benign entities such as corneal abrasion, traumatic iritis, corneal foreign bodies, and subconjunctival hemorrhage will very likely be discharged home, generally with instructions to follow up with ophthalmology. Although ocular trauma is not encountered frequently, having a stepwise approach to the evaluation and management will ensure adequate care of these patients and will provide them with the best chance of a favorable final visual outcome.

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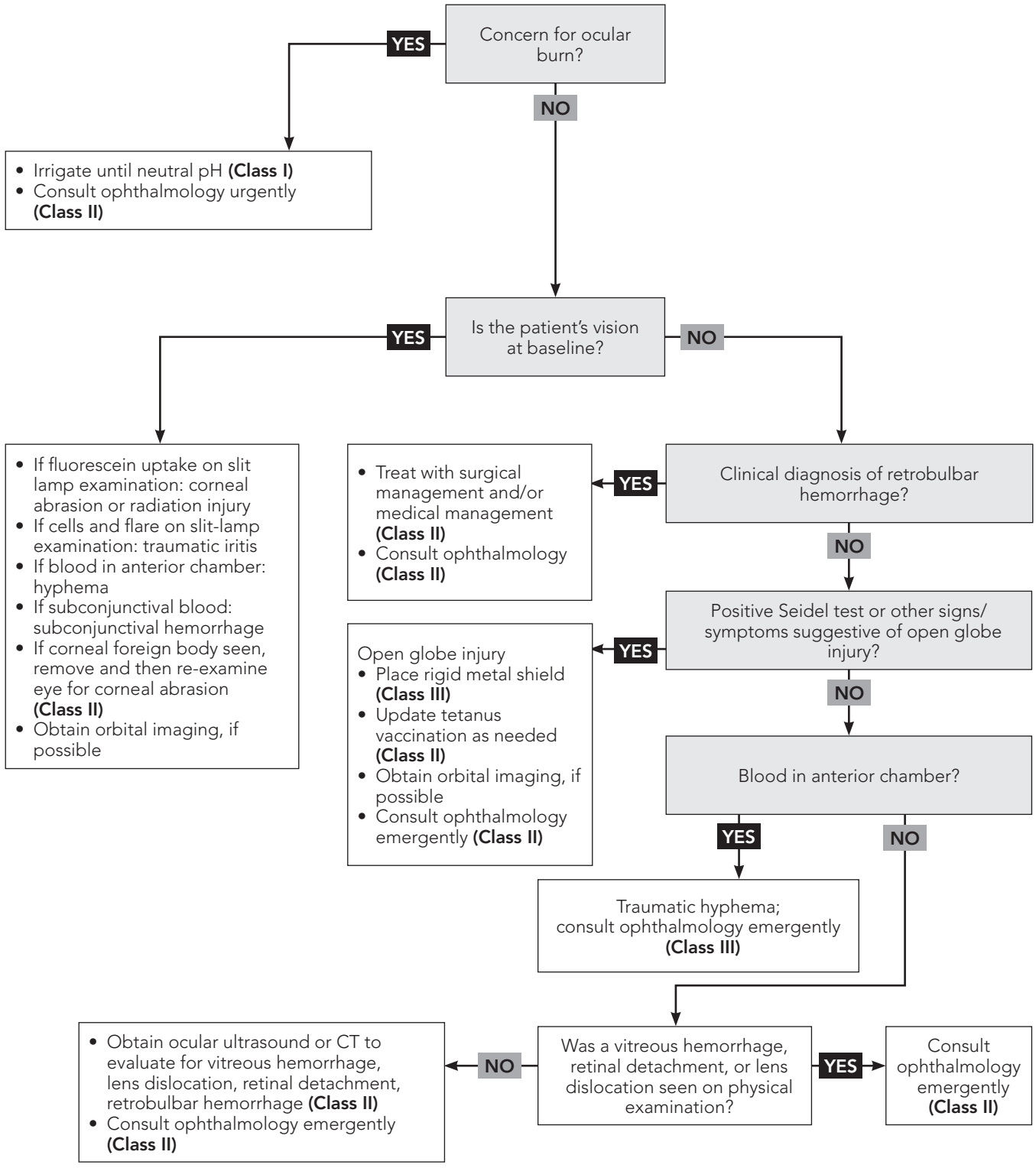
Clinical Pathway for Emergency Department Management of Ocular Trauma


Concern for ocular burn?
YES
NO
• Irrigate until neutral pH (Class I)
• Consult ophthalmology urgently (Class II)
Is the patient's vision at baseline?
YES
NO
• If fluorescein uptake on slit lamp examination: corneal abrasion or radiation injury
• If cells and flare on slit-lamp examination: traumatic iritis
• If blood in anterior chamber: hyphema
• If subconjunctival blood: subconjunctival hemorrhage
• If corneal foreign body seen, remove and then re-examine eye for corneal abrasion (Class II)
• Obtain orbital imaging, if possible
Clinical diagnosis of retrobulbar hemorrhage?
YES
• Treat with surgical management and/or medical management (Class II)
• Consult ophthalmology (Class II)
NO
Positive Seidel test or other signs/ symptoms suggestive of open globe injury?
YES
Open globe injury
• Place rigid metal shield (Class III)
• Update tetanus vaccination as needed (Class II)
• Obtain orbital imaging, if possible
• Consult ophthalmology emergently (Class II)
NO
Blood in anterior chamber?
YES
NO
Traumatic hyphema; consult ophthalmology emergently (Class III)
Was a vitreous hemorrhage, retinal detachment, or lens dislocation seen on physical examination?
YES
Consult ophthalmology emergently (Class II)
NO
• Obtain ocular ultrasound or CT to evaluate for vitreous hemorrhage, lens dislocation, retinal detachment, retrobulbar hemorrhage (Class II)
• Consult ophthalmology emergently (Class II)

*For class of evidence definitions, **see page 28**.*

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■ Time- and Cost-Effective Strategies

- Many ophthalmic medications are quite expensive, and the emergency clinician should be aware of this, particularly if the patient is uninsured or has a high prescription copay. Some medications are on the "$4 per month" list, available at many pharmacies, so local pharmacies should be consulted to see if any common ophthalmic medications are on this list. Many of these lists are available online. Erythromycin ointment, gentamicin solution, polymyxin B sulfate/trimethoprim solution, and tobramycin solution are generally on this list. Topical NSAIDs often cost $50 or more, as do cycloplegics, aminocaproic acid, and topical fluoroquinolones.
- Bedside ocular ultrasound is a skill that all emergency clinicians should strive to learn. It is not a difficult procedure to perform, and it can have a profound impact on the patient's management. It may obviate the need for a formal CT, saving time, money, and radiation exposure. While ultrasound should be attempted, and it may increase the speed with which it is diagnosed, a negative ultrasound may be encountered and does not rule out retrobulbar hemorrhage. As such, a lateral canthotomy is still recommended if the clinical scenario indicates a retrobulbar hemorrhage.
- Ophthalmology should be consulted early in the patient's clinical course once a vision-threatening injury is suspected or diagnosed. In many of these cases, the patient's treatment and disposition will hinge on the ophthalmologist's recommendation.
- Wearing eye protection for procedures in the ED, particularly those that involve body fluids, is an inexpensive and effective method to prevent the need for post exposure prophylaxis.

■ Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care. Copyright © 2023 EB Medicine. www.ebmedicine.net. No part of this publication may be reproduced in any format without written consent of EB Medicine.

Risk Management Pitfalls in Emergency Department Management of Ocular Injuries

1. **"I didn't have time to do proper visual acuity testing."** Visual acuity is, essentially, a "vital sign" of the eye. Formal visual acuity testing with a Snellen chart or other device typically takes <2 minutes and is an essential component of the patient's physical examination. If the patient is unable to complete this, then a rough estimate of the patient's visual acuity should be obtained. Can the patient count fingers, see a hand waving, or read? There may be later medicolegal implications regarding visual acuity, particularly in cases of workers' compensation, so this must be documented.[7,18,25]

2. **"I thought I should examine the patient's eye prior to irrigation."** The patient's best chance of a favorable visual outcome following an ocular chemical burn is immediate and copious irrigation. Even if other life-saving measures must be instituted simultaneously, irrigation should begin immediately. Whatever fluid is most readily available (eg, normal saline, lactated Ringer's solution, tap water) should be used.[6,11,12] Record the length of time of irrigation, the solution being used, the pH of the eye, and the times when the pH of the eye was tested.[51] Additionally, it is the responsibility of the emergency clinician to ensure that triage staff is aware of the time sensitivity of irrigation in these patients so that they are treated expeditiously.[85]

3. **"I didn't realize I had to record so much specific information about the trauma."** It is extremely important from a medicolegal standpoint to record specific information regarding the trauma. If the patient presented with visual complaints without a clear history of trauma, ascertain and record what they were doing at the time of onset of symptoms, as heavy lifting may be the "trauma" that precipitated the ocular injury (eg, retinal detachment). This is also very important for workers' compensation cases.[20] Ocular pain while hammering or performing some other metal-on-metal activity is also important to elicit, as it places the patient at risk for an intraocular foreign body.[1]

4. **"The patient had severe trauma with other life-threatening injuries, so I didn't really examine his eyes."** The fact that a patient may have life-threatening injuries or a swollen face that precludes direct examination of the globe does not absolve the emergency clinician of the responsibility to evaluate for and treat vision-threatening injuries. CT of the orbit can be very helpful and unlikely to delay care, particularly if the patient is already receiving a CT of the head. If the patient is not stable enough to leave the ED, bedside ultrasonography is a good way to evaluate for vision-threatening injuries.[32,33,36]

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5. **"I already examined the eye once, why do I need to examine it again?"** If the patient has any change in symptoms or if any procedure is performed on the eye (eg, corneal foreign body removal), the eye should be re-examined and these results should be recorded. Changes in the patient's symptoms may indicate an evolving pathology that requires attention, and the eye should be re-examined to evaluate for this possibility.[86]

6. **"I thought that topical steroids were indicated!"** Although topical steroids may be used to treat a myriad of ocular conditions, they can be potentially harmful to the eye and their effects need to be monitored closely. Consider steroid treatment only in conjunction with ophthalmology consultation.

7. **"The patient's eye injury occurred at work and I forgot to ask whether she was wearing any eye protection."** Knowing whether or not the patient was wearing eye protection is particularly important, especially if the trauma occurred at work.[7] The patient may ultimately require workers' compensation.

8. **"My patient states that he cannot follow up with his ophthalmologist until next week. I thought that was soon enough."** This depends on the ocular injury sustained. However, generally, the patient will need much closer follow-up, often within 24 hours. The inability to follow up must be taken into consideration when formulating a treatment plan for a patient.

9. **"I thought all corneal abrasions were managed the same way."** It must be discerned whether the patient with corneal abrasion wears contact lenses. If contact lenses are worn, then the patient will need a topical antibiotic that has antipseudomonal properties, and the patient must be instructed not to wear contact lenses until the corneal abrasion has resolved.[15]

10. **"The Seidel test was negative, so I didn't think the patient had a globe rupture."** The Seidel test can be negative if the area of globe rupture or laceration is small and has sealed off. A high index of suspicion must be maintained, primarily based on the mechanism of injury.[2,18,26] Ultrasound and CT can aid in the diagnosis of a globe rupture.[32,33,36]

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Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

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■ CME Questions

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1. **In which of the following cases should treatment for the injury begin prior to evaluation of the injury?**
   a. Corneal abrasion
   b. Ocular chemical burn
   c. Traumatic iritis
   d. Subconjunctival hematoma

2. **What physical examination maneuver should be performed in a patient with multiple linear corneal abrasions seen on fluorescein examination?**
   a. Slit-lamp examination to look for cells and flare
   b. Orbital CT to look for an intraocular foreign body
   c. Tonometry to evaluate for elevated intraocular pressure
   d. Eversion of the eyelid to search for a foreign body

3. **Proptosis can be caused by which of the following?**
   a. Bony displacement into the orbit (blow-in fracture)
   b. Retrobulbar edema
   c. Retrobulbar hemorrhage
   d. All of the above

4. **A 2-year-old boy presents to the ED with a traumatic hyphema. He is Black and was recently adopted; his medical history is unknown. Which of the following laboratory tests would be the most beneficial to obtain in this patient?**
   a. Complete blood count
   b. Basic metabolic panel
   c. Sickle cell screening test
   d. Blood cultures

5. **A patient was cutting wood when he felt something fly into his eye. He had immediate pain. Orbital CT was within normal limits. Which of the following is the next best imaging study to obtain on this patient to evaluate for an intraocular foreign body?**
   a. CT with intravenous contrast
   b. X-ray
   c. Magnetic resonance imaging
   d. No further imaging is necessary since the CT was within normal limits

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6. **Which of the following would be the most useful in evaluating an unstable trauma patient with significant periorbital swelling?**
   a. Bedside ocular ultrasound
   b. Computerized tomography
   c. Magnetic resonance imaging
   d. Slit-lamp examination

7. **Which of the following should be performed in addition to a lateral canthotomy in the treatment of retrobulbar hemorrhage?**
   a. Superior cantholysis
   b. Medial canthotomy
   c. Inferior cantholysis
   d. Dissection of Whitnall tubercle

8. **Which of the following injuries is the least likely to necessitate hospital admission?**
   a. Traumatic lens dislocation
   b. Traumatic iritis
   c. Traumatic vitreous hemorrhage
   d. Traumatic retinal detachment

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Points & Pearls

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Ocular Injuries: Emergency Department Strategies

Points

- Perform a fluorescein examination to identify any corneal abrasions and to test for a possible ruptured globe via the Seidel test.
- Perform fundoscopy and a portable slit-lamp examination to examine the cornea and iris for foreign bodies as well as for cells and flare indicating traumatic iritis.
- Proptosis may indicate an underlying retrobulbar hemorrhage.
- Obtain intraocular pressure by palpation of the globes if tonometry is not available.
- Obtain and record visual acuity for all patients. A rough estimate (eg, counting fingers) is acceptable if formal assessment is not possible.
- In multiply injured patients, assess for vision-threatening injuries at the end of the primary examination.
- Anticoagulated patients are more likely than nonanticoagulated patients to suffer traumatic hyphema, retrobulbar hemorrhage, subconjunctival hemorrhage, and vitreous hemorrhage.
- Screen for sickle cell disease or sickle cell trait in Black patients with traumatic hyphema, as patients with these conditions have a higher incidence of secondary hemorrhage.[31]
- Helical CT is quicker than conventional CT and involves lower radiation exposure. CT is considered the gold standard but can miss vegetable foreign bodies and some small foreign bodies.
- Many ocular conditions can be diagnosed by ultrasound **(see Table 3)**.
- Emergent ophthalmology consultation is needed for retrobulbar hemorrhage, open-globe injuries, retinal detachment, vitreous hemorrhage, posterior vitreous detachment, or lens dislocation
- If the clinical diagnosis of retrobulbar hemorrhage is unequivocal but the ophthalmology consult will be delayed, a lateral canthotomy with inferior cantholysis should be performed by the emergency physician. Permanent visual damage is unlikely if decompression is performed within 2 hours of symptom onset.[30]

Pearls

- Irrigation of ocular chemical burns should be started immediately, with whichever irrigation fluid is available (including tap water). All ED staff should be made aware that this takes priority over the history and physical examination.
- Consider bedside ocular ultrasound when there is too much soft-tissue swelling to retract the eyelids and examine the orbit properly.
- Antifibrinolytics may reduce rebleeding in traumatic hyphema, but no other therapies (including corticosteroids, cycloplegics, miotics, or patching) have been shown to be helpful.
- Patients with sickle cell disease should not be given carbonic anhydrase inhibitors, which increase the tendency of the red blood cells to sickle in the anterior chamber.[15,23]
- Patching is not recommended for corneal abrasions.

- If retrobulbar hemorrhage is suspected but the diagnosis is not definitive, medical management with mannitol, corticosteroids, and acetazolamide should be provided.
- To prevent further injury while awaiting ophthalmology consultation for an open-globe injury, place the head of the patient's bed at 30°, apply a rigid metal shield, and administer analgesics and antiemetics.
- For ocular burns, thoroughly irrigate the eye, apply a topical antibiotic, and give a tetanus immunization if indicated. All other medications given should be at the discretion of the treating ophthalmologist.
- Corneal foreign bodies should be removed if they are not penetrating.
- Patients with corneal abrasions who wear contact lenses require antipseudomonal coverage and daily evaluation until the abrasion heals.

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